THE
LONGLEAF PINE IN VIRGIN FOREST

A SILVICAL STUDY

BY

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ILLUSTRATED

FIRST EDITION

FIRST THOUSAND

NEW YORK
JOHN WILEY & SONS
LONDON: CHAPMAN & HALL, LIMITED
1907

ROBERT DRUMMOND, PRINTER, NEW YORK

Preface

THE study included within these pages is offered as a short contribution to the life-history of one of our most important forest trees. It is addressed primarily to foresters and forest students, owners and managers of Southern pine timberlands, as well as to all those persons who take a general interest in the welfare of our forests.

A knowledge of the habits and requirements of our trees is one of the underlying and essential conditions for the application of practical forestry. Each tree among the many kinds has its peculiar characteristics and is gifted with its own powers of resistance or adaptability; each shows distinct preferences or dislikes for particular conditions of soil, climate and environment. This relation to outward circumstances, sufficiently complicated for the individual tree, becomes far more so where many trees are intermingled as in a forest.

The study of our forests from this point of view is comparatively recent. From the nature of the subject a full knowledge of the life-histories of our trees can be gained but slowly. Consequently the study before the reader can lay no claim to completeness, but its purpose will have been achieved if it has presented new facts of practical value or suggested new methods for further investigation.

The writer wishes here to express his sincere thanks to those who have in any way assisted in the preparation of this essay, and in particular to Mr. Gifford Pinchot, Chief of the Forest Service, U. S. Department of Agriculture, and Professor Henry S. Graves, Director of the Forest School of Yale University, for their valuable criticism and suggestions.

The practical investigation in the field was greatly facilitated through the kindly suggestions of the late Dr. Charles Mohr of Mobile, Alabama, whose long and intimate acquaintance with the entire range of the Southern pines enabled him to give excellent advice regarding the most favorable regions for study.

The photographs from which the illustrations have been derived, with the exception of Fig. 4, while taken by the writer and here published for the first time, now constitute part of the collection of the U. S. Forest Service. Special acknowledgment is here made for permission to use them in the present volume.

Fig. 4 and the cover-design have been reproduced from a photograph for which the writer is indebted to the kindness of Mr. J. Conrad Rueter of Jamaica Plain, Mass.

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Introduction

THE virgin forest offers excellent opportunities for studying the life-histories of trees. Under primeval conditions the peculiar characteristics and natural tendencies that belong to each tree as a species are enabled to assert themselves independently of the complications so frequently resulting from human interference. Under such circumstances, therefore, tree habits become unusually suggestive and interesting, and conclusions may often be drawn with more certainty than where man has interfered with the various factors of life.

Several investigations of the life-history of the longleaf pine, including observations under virgin forest conditions, have been made within recent years. There is, however, a practical value in pursuing still further the study of this tree. The longleaf pine is commercially of the very first importance. It is extensively distributed throughout one of the best timber-producing sections of the United States and is very well adapted to systematic forest management. Within recent years new and improved methods of exploitation have been adopted by certain owners of large timber tracts, but many pineries are still managed with too little regard for the future and the supplies are quickly melting away. Only when the treatment of these forests shall be brought into accordance with the natural requirements and life-tendencies of the tree will the best results for the present as well as the future be assured.

The present study was undertaken by the writer several years ago and extended over selected localities in the Gulf States from western Florida to western Louisiana. Although thus limited to a part of the natural longleaf pine area, which extends from southern Virginia to eastern Texas, it is believed that it was extensive enough to furnish the material for a truthful account of some of the most important silvical facts regarding this tree.

The Longleaf Pine in Virgin Forest

I

Character of Virgin Longleaf Pine Forests

THE longleaf or yellow pine (*Pinus palustris* Miller) occupies a belt of land, rarely more than 125 miles in width, extending from the boundary of Virginia and North Carolina southwestward through the Atlantic Plain into central Florida, and thence westward around the Gulf to within a short distance of the Mississippi River. Detached bodies of longleaf pine also grow in the Red River region of Louisiana and between the Sabine and Trinity rivers in southeastern Texas. The loblolly, Cuban and shortleaf pines extend over parts of this area, but the longleaf pine is the dominant tree and generally forms extensive and continuous forests by itself.

Within the Gulf region, to which this study was chiefly confined, the distribution of the longleaf pine from the coast inward is somewhat similar to its distribution in the Atlantic Plain. On the low, marshy lands in the vicinity of the Gulf it is largely replaced by the Cuban * and loblolly pines. Proceeding inland, the surface of the country rises very gradually. Here the longleaf pine covers the sandy hills and plains, while the moist depressions bordering the creeks and streams are occupied by hardwoods, loblolly pine and cypress. Still farther inland the country becomes broken and hilly and the longleaf pine, as in the Atlantic section of the belt, mingles with the mixed hardwood and shortleaf pine forests of the uplands. (See map.)

The forests on the Atlantic side have undergone many changes as a result of lumbering, fires and the boxing of the trees for turpentine. Virgin forests of longleaf pine are consequently confined at present almost entirely to the States bordering the Gulf. By far the greater part of these virgin forests are purely longleaf growth and may be classed appropriately under one general type with certain minor variations. The remainder, situated farther

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* On the Atlantic side the Cuban pine does not extend northward beyond southeastern South Carolina.

inland from the Gulf, differ mainly in the fact that the longleaf pine is associated with a number of other species. A short account of the general conditions of growth within each of these types is necessary before the life-history of the longleaf pine can be taken up in detail.

In the larger type, that of the "pure" forests, the stand of trees is open to moderately dense. The heights are fairly uniform, while the diameters, although ranging within somewhat wider limits, are at least uniform for virgin forests. The boles are almost invariably straight and are more cylindrical in form than those of most trees. The crowns, which usually occupy at least the upper third of the tree, are conspicuously open, especially in their lower parts. (See Fig. 1.)

A more definite idea of the closeness of the stand and the sizes of the trees shown in Fig. 1 can be obtained from Table I, which has been compiled from measurements of trees immediately adjoining those shown in the illustration.

The undergrowth, surfacegrowth and soil conditions are simple in character. The undergrowth consists mainly of scrubby forms of oak and occasional bushes of dogwood and gallberry, scattered here and there through the forest. Sometimes the

TABLE I.

ONE ACRE OF VIRGIN LONGLEAF PINE FOREST.
BALDWIN COUNTY, ALABAMA.

Diameter at breast-height. Inches.	Number of trees.	Heights of five selected sample trees. Feet.
10	1	85
12	3	
14	6	100
16	9	
18	10	109
20	7	102
22	9	
24	4	114
26	3	
28	1	

oaks occur in dense clusters, but they rarely cover continuous areas like those so commonly found in the cut-over and badly burned pineries on the Atlantic side of the belt. Toward the hilly country of the interior, particularly in the more open spaces of the forest, the undergrowth increases; but here, too, the forest remains essentially one of pure longleaf pine.

The surfacegrowth consists of various kinds of grasses, among which wire-grass (*Aristida stricta* Michx.) and broom-sedge or broom-straw (*Andropogon virginicus* L.) are the most common. The broom-sedge is the taller and stockier of the two, and

Fig. 1.—Typical Virgin Forest of Longleaf Pine.
Baldwin County, Alabama.

is especially noticeable in the vicinity of the coast and near the forest borders. The wire-grass, which varies from one to several feet in height, is more wavy in appearance and grows abundantly almost everywhere throughout the pine forests. In fertile places, and where protected from constantly recurring fires, its growth is characteristically dense and bushy. In localities that have escaped fire for a number of consecutive years a thin layer of pine-needles, small litter and rotted grass gradually accumulates on the soil, and in the denser parts of the forest the wire-grass is often replaced by a rich layer of mold several inches in depth.

The soil in these forests has been formed from the sands and gravels of late Tertiary times, and is underlaid by a stratum of clay at a depth varying from two to five feet. At the surface the sand is often nearly pure, or is bound only very loosely with clay to a depth of five inches or more. Generally this top-soil changes somewhat abruptly into a heavier, loamy soil below. With increasing depth the admixture of clay increases until the underlying layer of heavy, fatty, pure clay is reached. Toward the interior, where the surface of the country becomes hilly and irregular, the sands and gravels are partly replaced by calcareous loams and marls, which usually occupy the valleys and lower slopes. This is the region of mixed growth (see map), in which the longleaf pine gives way largely to oak forests and to loblolly and shortleaf pines, in accordance with changes in the soil.

The soil in the virgin longleaf pine forests of the Gulf region is generally better in quality than that of the cut-over lands on the Atlantic side. Since it has been less exposed to wind and rain by openings in the crown-cover of the trees and has been less frequently and severely burned over, a layer of forest mold has been preserved in favorable situations. The beneficial action of the mold upon the underlying soil is well known. It not only furnishes active solvents for the preparation of plant-food, but imparts to the soil a crumbly, porous consistency by the thorough mixture of its vegetable particles with those of the mineral rock. It thereby moderates the extremes of looseness and compactness and tends to an even distribution of moisture and temperature throughout the different layers of the soil. In meagre, sandy soils this improvement in quality is especially desirable.

Within the prevailing type of pure longleaf pine certain minor variations require explanation in order to bring out clearly the character of these virgin forests. The most important variation is in the density of the stand of trees. Besides the difference due to more favorable conditions of growth in particular localities, distinct differences also occur on very restricted areas. Ordinarily the stand of trees does not maintain its uniformity over more than a few hundred acres; often it changes abruptly even within fifty acres. Thus we may enter a stand of mature timber, with trees from 90 to 120 feet in height and with ample spaces here and there in the crown cover, giving entrance to the light from overhead. After walking perhaps only a few hundred paces, we may find the trees suddenly beginning to close up their crown spaces. They grow smaller and more numerous, until presently they form a tolerably dense grove; and then they open up once more into the original stand of mature, tall trees. Occasionally, too, a tract of old trees of fairly uniform height is replaced by one in which the trees show diversity in size, ranging from mere poles to veterans of the forest.

The dense groves of poles and tall saplings, though of constant occurrence in the virgin longleaf forests, are usually not over half an acre in extent, and in the aggregate form but a small part of the total area. On the whole, the forest is composed largely of

TABLE II.

Sample Acres of Typical Virgin Longleaf Pine Forest.

Plot No.	Locality, topography, soil.	Number of trees by 2-inch diameter-classes. (Diameters at breast-height.)																	Total number of trees per acre.
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	
1	Baldwin County, Ala. Low, rolling hills. Loamy sand, with clay subsoil. Humus, 1 inch.					1	3	6	9	10	7	9	4	3	1				53
2	Jackson County, Miss. Flats and low hills. Light, sandy clay; rather stiff red-clay subsoil; moist. Humus, 1 inch; in good condition.			2	5	7	20	24	15	9	8	2	1						93
3	Calcasieu Parish, La. Gently undulating. Sandy top-soil, with subsoil of clay at 1 to 3 feet. Wet and heavy in places. Humus, 2 inches.				1	1	10	9	13	10	13	8	4	1		1	1		72
4	Calcasieu Parish, La. Gently undulating. Shallow, sandy top-soil, with clay at 6 in. to 1 ft. Wet.		5	21	35	52	36	16	1	1									167
5	Calcasieu Parish, La. Level. Sandy top-soil, with clay subsoil at 1 to 3 feet.	4	33	50	26	23	18	5	2		1	2			1				165
6 (½ acre)	Catahoula Parish, La. Level. Shallow, sandy top-soil, with brittle red-clay subsoil. Humus, scant. Rather inferior soil.				2	1	1		2	2	1	5	4	1	4	2		1	52*

TABLE II.—(*Continued*).

Plot No.	Locality, topography, soil.	Total number of trees per acre.	Crown density.	Heights.	Clear lengths.	Remarks.
1	Baldwin County, Ala.	53	.5	Mainly from 85 to 115 feet.	Generally two-thirds of total height. Crowns very open in lower parts.	Mature forest; straight trees.
2	Jackson County, Miss.	93	.6	Mainly from 80 to 120 feet; mostly over 100 feet.	Not quite two-thirds of total height. Open crowns.	Additional, dying or dead: 3 small poles and 1 veteran.
3	Calcasieu Parish, La.	72	.6	Mainly from 90 to 120 feet.	Generally two-thirds of total height. Crowns very open in lower parts.	Represents good yield for western Louisiana and Texas. Additional dead trees: 7; various sizes.
4	Calcasieu Parish, La.	167	.8	80 to 110 feet, except trees under 8 inches in diameter, which are badly suppressed.	Generally three-quarters of total height.	Immature forest. Additional dead trees: 10 small poles, 1 large pole, 1 veteran.
5	Calcasieu Parish, La.	165	.7†	35 to 115 feet.	Generally two-thirds of total height.	Variation from uniform type to type of different sizes. Additional dead trees: 3 small poles.
6 (½ acre)	Catahoula Parish, La.	52*	.5	Mainly from 80 to 120 feet.	Two-thirds to three-quarters of total height.	Additional dead and burned trees: 6; various sizes.

* 26 for the ½ acre. † The crown density for plot 5 is variable, with an average of about .7.

trees that have passed the earlier and more vigorous stages of growth.

The variations in growth described in the two preceding paragraphs are represented by figures in Table II. The sample acres to which these figures refer were selected from various tracts within the Gulf region as typical examples of the character of growth of the main body of virgin longleaf pine. Plot 1 furnished the measurements given in Table I above.

An inspection of the table shows that the stands usually range within close diameter and height limits for virgin forest. Trees with small diameters are disproportionately tall, indicating an attempt to reach the all-important light. That the longleaf pine requires a large amount of light may also be inferred from the "Remarks" in the column at the right. Here it will be noticed that the dead and dying trees are usually of small size, which is explained by their inability to stand the shade of the larger trees.

It should here be explained that the figures in the column headed "Crown density" indicate the proportion of overhead light that is excluded by the crowns when the sun is directly overhead; in other words, the proportion that the horizontal spread of the crowns bears to the total area. A crown density

Fig. 2.—A Longleaf Pine Forest with Trees of Various Sizes. Escambia County, Florida.

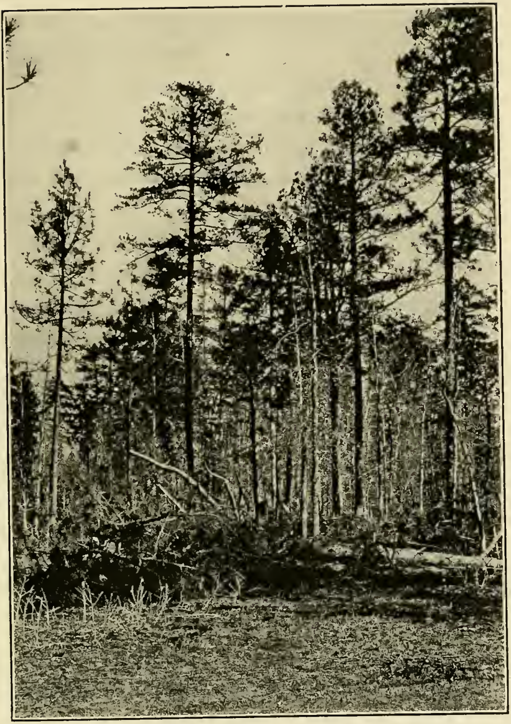

Fig. 3.—Longleaf Pine in Mixture with Shortleaf Pine and Hardwoods. Caldwell Parish, Louisiana.

of .5, for instance, would indicate that one-half the area is screened by foliage.

In plots 1, 2, 3 and 6 the comparatively small number of trees and the low crown densities indicate mature forest growth, in which an originally denser stand has been weeded out by death and decay. Plot 4 is evidently a somewhat younger forest, in which a larger number of trees are able to live in more crowded positions. Plot 5 represents the departure from uniform to variable sizes. This variation from the main type is illustrated in Fig. 2.

The other type of forest, represented by the mixed growth of the interior hill country, is determined very largely by changes in the composition of the soil. As already indicated, the hills are capped by sands, gravels and sandy loams, to which the longleaf pine is very largely confined. The stand is of moderate density, but the trees show rapid growth and a large number attain maximum size. Farther down the slopes the soil merges into the richer loams and limestone soils occupied by the oaks, hickories and other deciduous species, and by shortleaf and loblolly pines. Along the lines of separation the longleaf pine has to contend for its ground, and the result is a heterogeneous or mixed forest of variable sizes. (See Fig. 3.)

II

Natural Rotation: Evolution in the Forest

IN the renewal of a virgin forest the result of the competitive struggle that is continually in progress, as one generation of trees succeeds another, depends largely upon the special requirements of the different kinds of trees and their adaptability to the conditions to which they are subjected. Where the forest is composed of a single species the study of its life-history is much simplified, because the conflicting requirements of different kinds of trees do not enter into the problem of future development.

The well-defined range of the longleaf pine along the warmer sections of our coast indicates how essential to its existence is a moist atmosphere and a mild climate. That it is able to adapt itself to a comparatively poor soil is also evident from its distribution: it is confined almost entirely to the meagre sands, gravels and pebbly deposits of the later Tertiary formations. Its astonishing power of resistance to fires, except during very early life, points to the possibility of at least a partial renewal, in spite of the many destructive human agencies that are constantly threatening it. On the other hand, its inability to tolerate shade increases the difficulty which this tree has in penetrating into forests composed of other species, and even has a very important bearing on its own form and development in those forests in which it is the sole constituent species.

Since the soil and climate within the region covered by this study generally meet the conditions for a satisfactory growth, and since the uniform topography offers no special complications, the study of natural rotation in these forests will chiefly have to do with such questions as tolerance, fires and the effects of different ground covers. Before these questions are studied in detail, however, it is desirable to give a general account of the actual way in which the trees succeed one another.

The first requirement for succession in the forest is a supply of seed. The longleaf pine produces this at a comparatively early age, although the exact period, as with other species, depends in some measure upon modifying conditions, such as the fertility of the soil and the warmth, moisture and light at the disposal of the tree. Seed years come only at intervals, usually about five years apart; but after prolonged periods of rest a seed year is likely to occur that is exceptionally prolific. During a seed year small poles can frequently be seen bearing a few cones, while larger trees bear very heavily. Prolific seed years, or "heavy masts," are known to have taken place in 1845, 1872 and 1892.*

During this study, which was undertaken in January, 1901, cones that dated from the year 1899 were occasionally found under small poles over the entire region examined. In seed years that are only moderately productive such an addition to the larger supply furnished by the older trees must be very helpful. If the forest should meet with some calamity before reaching maturity, as, for example, a windfall, the seed supply of such of the younger trees as might remain standing would help to perpetuate the stand. Ordinarily, however, the seed supply is not needed before the forest has reached its older stages of development, because in most cases it is not before the large, old trees die that

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* Bulletin 7, North Carolina Geological Survey.

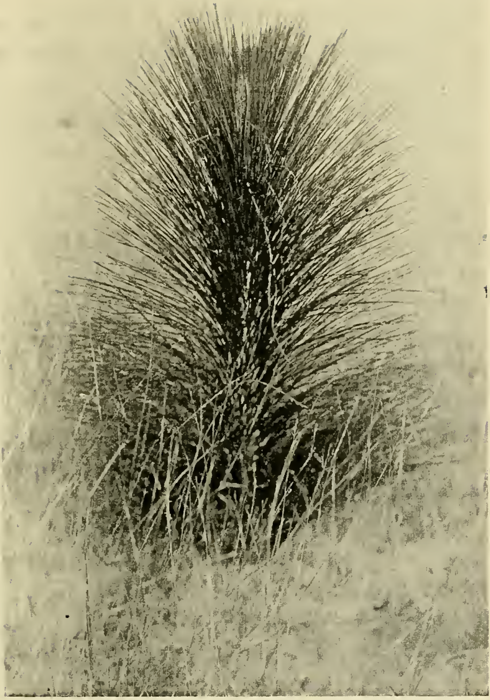

Fig. 4.—A Young Longleaf Pine, the Forerunner of the Forest.

the light which is so urgently required by a new generation of longleaf pines can be supplied. In any event, however, the periodic interruptions in the production of seed must be regarded as unfavorable to a natural succession in longleaf pine forests.

When the seed falls it must alight upon a favorable seed bed to germinate. Thereafter the young plant will depend for its development upon the necessary conditions of light, warmth and moisture, and upon its power to resist untoward influences and the dangers to which it is exposed. Henceforth it forms part of the forest and its future is bound up with the changes that take place in its immediate surroundings. (See Fig. 4.)

Among the various influences that affect the lives of young trees in longleaf pine forests there is perhaps none that has such a significant bearing upon their development as the influence of light. This shapes the life of the forest in a remarkable way, and determines not only the time and place, but also the manner in which the trees shall succeed one another, and what the characteristic form and aspect of the forest shall be. An account of the manner in which this happens will make clear how the longleaf pine forests come to have the character and variations in growth already described.

The light that is required for a new generation of trees is admitted through openings in the crown cover. Small openings are caused by the fall of one or several large trees as the result of old age, disease,* lightning or windstorms. Larger openings are similarly caused by hurricanes and severe storms. In some instances such larger openings are also caused by the premature death of groves of timber, due to special conditions that will be discussed later on.

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* A very common fungous disease in these longleaf pine forests is one known as "red-heart." In some localities as many as half the trees per acre were found to be affected with it in the crowns, though the trees were still alive and utilizable in the lower half of the stem for timber. Bulletin 13 of the U. S. Forest Service gives, on page 63, the following explanation:—

"Frequently full-grown trees are found to show signs of rapid decay. These are recognized by the gradual dying of the smaller limbs and their falling off, in consequence of the rotting of the wood surrounding their base; and after having been cast off a hole or diseased spot remains in the trunk, which is infested by a large fungus of the genus *Polyporus* (punk holes, punk stools). The heartwood of such trees is of a reddish color, soft, sappy, and full of small channels, caused by the breaking down of the walls of the wood-cells filled with the mycelium, the so-called spawn of the fungus, the threads of which also penetrate the medullary rays. Such punky or red-heart timber is found mostly on the ridges in the poorest soil. Apparently superannuated trees are most frequently found afflicted with this rot."

FIG. 5.—A LONGLEAF PINE SAPLING GROWING WITHIN A GROUP OF BLACK JACK AND TURKEY OAKS.

The logs in the background are from a very recent cut.

The smaller openings are very noticeable in the forest and are the occasion of dense groves of young trees, locally known as "sapling thickets." But these openings are not, as a rule, immediately occupied by young growth. It will be remembered that the seed years occur only at intervals, while reproduction is still further hampered by the constant battle that the young trees have to wage with fire. Consequently it may happen that some of the species of oaks, originating from seeds of trees growing in the neighborhood, first avail themselves of the advantage of a free open spot, and, by shading out the place, increase the difficulty that young pines have in establishing themselves. In such cases it is only here and there that the pines will find a small space among the young oaks and ultimately they will form an open stand. (See Fig. 5.) If the new growth of oaks is unusually dense the pines may even be crowded out altogether.

Where a small opening is caused by lightning, the tree which has been struck sometimes catches fire, thereby injuring the neighboring trees and weakening the group to such an extent as to expose it to the attacks of bark beetles. An instance of this kind was observed in western Florida.

In the case of larger openings the effect on the forest is more complicated. A few selected cases, however, will readily explain the ruling principle of light and shade.

In St. Tammany Parish, Louisiana, a tract of old pines covering about ten acres was almost completely leveled by a hurricane nearly sixty years ago. It was soon followed by a new, dense growth of the same species, which, when examined, formed a stand of .9 density, with diameters ranging from 5 to 10 inches, and heights from 50 to 60 feet.

Another windfall, a few miles distant, occurred about the year 1890 and extended over approximately the same area. The storm, however, was less destructive, and uprooted only about one-quarter of the original stand. When examined in 1901 the trees remaining from this stand averaged hardly .4 crown density, and varied in size from full-sized poles to trees 15 inches in diameter. The new generation that had established itself since 1890 was scant, notwithstanding a heavy mast in 1892 and a light one in 1899. It should be remembered that at the time of the first mast the prostrate trunks and boughs in the openings probably shaded the ground, and for a year or two supplied fuel for severe fires. In openings of less than 150 feet in diameter only a few seedlings of the year 1899 were found, and these, as a rule, had been killed by fire. But in a few of the larger openings the seedlings averaged as many as eight to every four yards square. Some of these seedlings had successfully withstood still more recent surface fires. One of the larger openings is seen in Fig. 11, where a grass surface fire that has just passed over the ground has exposed to view the seedlings growing there.

In such a forest, unless the old trees still standing should be uprooted by a second hurricane, the regeneration in the smaller openings must necessarily be slow and uncertain, depending either upon the gradual removal of more trees to enlarge the opening or upon a prolific mast followed by exemption from fire for two or three successive years. The ultimate forest will be one of variable sizes and ages.

In Winne Parish, Louisiana, in 1873, a destructive hurricane cut a path three miles in length by a quarter of a mile in width through an old and comparatively dense virgin forest of longleaf pine, leaving but a few scattering trees. The region is one in which the longleaf forests are interrupted here and there by tracts of broadleaf species mingled with shortleaf and loblolly pines, the mixed forest usually occupying depressions and the borders of creeks and small watercourses, where the soil is richer, loamier and deeper than on the upland surfaces. The soil on the site of the windfall, however, was typical of the longleaf forests. With the exception of oaks, the nearest trees of the other species named stood not less than one-half to three-quarters of a mile away. The tract itself was surrounded on all sides by virgin longleaf pine.

The conditions, therefore, seemed very favorable for a succession of the same species. Nevertheless, the number of longleaf pines included in the present stand, as based upon a careful examination of different parts of the area, proved to be surprisingly small. The results of the estimate were as follows: oaks, about 500 per acre, mostly sprouts; shortleaf pine, 50 per acre, saplings and low poles, one-half sprouts; loblolly pine, 20 per acre, saplings and a few low poles; longleaf pine, 3 or 4 per acre, seedlings and saplings.

The explanation, after all, is not very difficult. The windfall occurred in the year succeeding the mast of 1872, too late for seedlings from that mast to establish themselves. Probably a number of years elapsed before another seed year occurred. Meanwhile the other species mentioned took possession of the ground, notwithstanding the occasional

FIG. 6.—DEAD TIMBER OPENING IN VIRGIN FOREST.

recurrence of severe surface fires; for two of the species, the oaks and the shortleaf pine, are capable of sending up sprouts from burned stubs. The intervening moderately prolific seed years of the longleaf pine were only partially successful, because seedlings of this species are in especial danger from fire during the first year or two of their lives.

Next in importance after windfalls dead timber openings, varying in size from half an acre to several hundred acres, and locally known as "deadenings," frequently open the way for regeneration in these pineries. (See Fig. 6.) The reason for the death of such large groves of trees could not be traced with certainty. A considerable number were noticed in southwestern Louisiana, the "deadenings" having taken place in large part about ten years ago. They varied in size from five to ten acres and were generally located in sags and other low places where the soil was unusually wet. (See Fig. 7.) Insufficient aëration in the soil may have caused the death of these groves, or at least hastened the end of the older and weaker trees. In several of the "deadenings" almost all the trees had been attacked by bark beetles. These insect ravages may possibly have preceded the insufficient drainage that presumably occurred in years of excessive rainfall, and may thus have been the direct cause of the "deadenings"; but it appears more likely that both of these causes contributed to the final result, since the areas in question were usually confined to low, wet ground.

Regeneration in such places meets with many difficulties. As the site is predisposed to be wet and soggy it is generally unfavorable to germination, and especially so during very rainy seasons. The trees along the edges, if attacked and weakened by bark beetles from the interior, are not promising seed bearers. Moreover, in large openings the transportation of seeds by the wind to the middle of the area will always be somewhat uncertain. If the grass is rank and tall, which is the more likely on damp, low ground, where fires are less frequent, its thick, bushy growth may prevent many seeds from reaching the soil; while at the same time it constitutes a threatening danger to the few seedlings that now possibly make their appearance, by furnishing the conditions for an unusually severe fire. The dry limbs, loose bark and decaying stems of the dead trees add to this danger.

The difficulties thus placed in the way of regeneration in dead timber openings will readily explain why some of the longleaf pine forests of western

Fig. 7.—Wet Soil in Western Louisiana, as shown by Stagnant Water remaining four Days after a Rain.

The gash in the soil was made by skidding a log.

Louisiana are not as uniform as those situated east of the Mississippi. Regeneration is likely to take place in stages. Plot 5 in Table II is evidently the result of an interrupted succession in the forest growth, though apparently due to other causes than those just explained, because the soil conditions are normal. It should be noted, however, that even such irregular forests tend to grow more uniform with age, on account of the exceeding intolerance of the longleaf pine.

In concluding these observations on the evolution of forest growth in small and large openings, it is worth while to glance once more at plots 3 and 4 in Table II. They are from the same region as plot 5, and each probably originated in great part from a single mast; for the trees of small diameters were usually found on examination to have the same age as the slightly larger trees. By reference to the columns at the right it will be noticed that the heights and clear lengths in the two plots do not differ greatly. This is important for the timber owner and shows that a denser stand of trees, as in plot 4, has comparatively little effect on the form of the longleaf pine. In most other forests the great value of a dense stand is its ability to produce straight, clean, lengthy boles. Owing, however, to the need of the longleaf pine for overhead light, or light descending from the higher angles, even comparatively open stands of this tree produce such timber, and produce it more rapidly than where the density is greater.

III

Tolerance

THE preceding account of windfalls has shown that the longleaf pine requires a large amount of light for its healthy development. It is now intended to convey a more definite idea of how much light is needed.

The following table represents the growth on a ¼-acre tract selected within the site of a small windfall of 1870, in Escambia County, Florida. The tract was in the form of a strip extending from the edge of the windfall toward the center. The stand, which consisted entirely of longleaf pine, had a crown density of .5. The windfall was surrounded by virgin forest.

TABLE III.

RESULTS OF A WINDFALL OF 1870. AREA: 1/4 ACRE.

1. Old trees remaining from previous forest	2
2. Trees from 2½ to 6 in. in diameter and 25 to 40 ft. in height	47
3. Trees from 1 to 2½ in. in diameter and 6 to 27 ft. in height	45
4. Saplings under 6 ft. in height	32
5. Large seedlings	9
6. Yearling seedlings	None

It will be remembered that heavy masts occurred in the years 1872 and 1892. Some of the trees in line 2 were cut down and found to be about 28 years old.* Undoubtedly a large number of the trees in line 3 belong to the same seed year, but were retarded in their growth by taller trees that overshadowed them. The remainder, including the trees in lines 4 and 5, must be referred chiefly to the heavy mast of 1892, but partly also to less prolific masts of the twenty years preceding. The decrease in numbers in lines 2 to 6 is significant, because it shows how the later growth finds it more and more difficult to gain a foothold as the forest grows taller and older. That the area did not fill up in the beginning may be ascribed to surface fires, which are known to have occurred in the earlier years.

Not far from this area a sapling thicket was examined that dated from about the year 1850. Sample trees of all the prevailing sizes were measured and their ages determined as nearly as possible from the rings near the butt of the tree. The ages could be determined only approximately, because the rings of growth during the first four or five years are very difficult to distinguish in the longleaf pine.

* The examination was made in January, 1901.

In Table IV the heights and diameters in italics indicate which trees were exceptionally slow in their development as compared with others of the same

TABLE IV.

SAMPLE TREES FROM A SAPLING THICKET.

Age.	Height in feet.	Diameter in inches at breast-height.
27	*13*	*1*
27	20	2
28	22	2
29	*19*	*1.5*
29	*19*	*2*
29	24	2
29	24	2
33	26	2.5
39	*20*	*2*
39	37	2.5
39	40	3
39	44	4
40	*34*	*2.5*
40	*34*	*3*
40	*35*	*2.5*
40	40	3
40	40	3.5
40	47	4
42	*36*	*2.5*
44	47	3.5
50	49	5
50	62	6.5

age. Their appearance indicated that suppression in the shade was the principal cause. It is worth noting that no trees were able to establish themselves within the last 27 years, although the grove 27 years ago and for some time after must have been much opener than now. The density at the time of observation was .8.

The taller the trees in a forest the less must be the density to insure a successful regeneration. Under ordinary circumstances an evenly distributed density as low as .3 is probably required in the mature forest of longleaf pine to insure an ample growth of seedlings; but in a fairly even-sized thicket of young saplings, let us say from six to twelve feet in height, it is safe to say that the density may rise to .7 or possibly to .8, without serious interference to new growth. The reason for this difference lies in the fact that in the low forest the morning and afternoon rays, though descending at an oblique angle, have practically an unobstructed course in the openings between the trees, and are therefore able to do effective work on the upper parts of the young plants; whereas in a tall forest of the same density the light must encounter may tall stems and the lower portions of large crowns on its way to the forest floor. In such a forest, if it be not very open, the light is always diffused and broken except about midday, and the most effective rays for intolerant species are therefore confined to the hours close to noon. It should be noted, however, that this disadvantage is relieved in some degree by the improved conditions of the soil for germination; since older, taller forests usually have a more equable temperature, greater humidity, a richer mold, and from what has just been explained, a more even and regular distribution of light.

The presence of direct and intense sunlight in low forests often enables a few longleaf pines to gain a foothold among comparatively crowded groups of turkey oak, bluejack and other low, scrubby oaks, which frequently invade openings among the pines. In such places a comparison of the ages of the young longleaf pines and the surrounding oaks usually shows that the pines, though taller, are hardly as old, or at least not older than their competitors, and that they were not, therefore, seriously affected by their shade. (See Fig. 5.)

The difference in the conditions of light in low forests, as compared with high ones of equal crown density, is of special interest in the case of the longleaf pine. The opening leaf-buds of this tree require for their further development a more vertical sunlight than most other trees—than any, in fact, with which the writer is acquainted. It is the intense light of midday that is required. Anybody who sees the longleaf pine for the first time will be surprised at the extraordinary length and bushiness of the needles, and at their characteristic habit of growing in upright tufts. The needles are so closely packed about the sides of the bud that the light must enter well from above to reach the bud effectively. The need for this overhead light is well illustrated in the sapling shown in Fig. 8. This young tree, after having been bent over by the fall of a larger one near by, was obliged to adjust itself to the changed conditions of light, and the result is shown in the very remarkable contortion of its branches. In Fig. 5 the same tendency to reach the overhead light appears in the angular forms and upright position of the twigs.

The disadvantage under which the longleaf pine may appear to lie on account of the length, position and density of its foliage, is indirectly of great benefit to the forester. It produces the straight boles that are wanted in the market and, by the early shading out of the lower branches in large trees, lifts the crown high, thereby producing long shafts and cylindrical forms.

Fig. 8.—Injured Longleaf Pine Sapling with Contorted Twigs, which show the Tendency to Vertical Growth in the Foliage of this Species.

The light has access from all sides to an angle of 45 degrees.

IV

Fires

FOREST fires have been common throughout the South for many years. They interfere so seriously with the development of the longleaf pine that they deserve careful consideration.

The fires in the longleaf pine forests are exclusively surface fires. In rank, high grass that has remained undisturbed for several years, a surface fire under a strong wind will sometimes scorch and brown the foliage of young trees as high as twenty-five feet above ground; but a real crown fire spreading through the forest, such as in the northern white pine region has often led to serious disaster and loss of life, has never come to the writer's knowledge within the longleaf pine region. The "ground" fires that eat their way slowly through peaty or otherwise inflammable soil are likewise unknown in the loose, sandy soil of the coastal pine belt.

These surface fires have a very important bearing on the life of the forest, and especially on the amount of new young growth and its future development. Figs. 9 to 16, which are reproductions from photographs of a surface fire that occurred in January in St. Tammany Parish, Louisiana, and lasted a full day, will explain better than words the character and action of surface fires. This fire was noticed by the writer in the early morning and before it had made much headway, although its immediate cause could not be ascertained.

Fig. 9 illustrates the beginning of the fire. It has come from some high grass this side of a damp depression in the distance, and in the illustration is advancing toward the observer and against the wind into the high grass in the foreground. At the left, where the smoke is rising noticeably, the fire is gaining headway. This will presently enable the wind to shift the direction of the fire and to drive it before the wind into the unburned grass in the background at the left.

Fig. 10 shows a section of the fire shortly after, still advancing into the wind diagonally from the left background into the foreground at the right, but prevented from spreading into the grass at the extreme right by a prostrate trunk.

Fig. 9.—A Surface Fire burning against the Wind.

FIG. 10.—A PROSTRATE TRUNK OPPOSING THE ADVANCE OF THE FIRE.

This obstacle to the spread of moderate surface fires is important enough to detain us for a few moments. It largely explains how young growth is able to gain a foothold now and then in forests where surface fires are of almost yearly occurrence. The illustration shows that restricted areas within the range of the fire occasionally escape, and as these areas are located among the fallen trees, where the light that is so much needed by young seedlings has found entrance, they are precisely the ones that are most in need of protection. The clean, long boles of the longleaf pine are especially well fitted to give it, because they insure close contact with the soil. Of course, two logs meeting at a wide angle or a succession of logs at intervals to re-inforce the protection, will be more effectual than a single log. During the first year or two, however, severe fires in the dead tops and litter of the fallen trees will prevent any seedlings from gaining a foothold within those parts of the area.

We may conclude from this that where a fire is traveling in the direction of a recent windfall the danger is greater than where it is traveling across. This is shown in Fig. 11, where the fire has just burned diagonally from the left into the background at the right, exposing to view scorched seedlings that had sprouted there. In the middle distance are seen the uprooted trees among the unburned grass, which has escaped on account of some preceding obstacle to the left of the picture.

Fig. 12 illustrates another kind of obstacle, which may prove effectual when the fire is not too violent or rapid in its course. In the middle foreground is seen a dark streak over which the fire has just passed into the distance beyond. The unburned grass at the left and right escaped because there were here slight depressions in the ground into which the fire failed to descend.

Fig. 13 illustrates a surface fire traveling against the wind across a wagon road from right to left on dry pine-needles. The latter are distinctly shown in the foreground where, also, at the right, little clouds of smoke indicate how the fire is feebly crossing to the opposite side. At the left is seen a small log that promises to oppose a section of the advancing fire. Incidentally this picture illustrates what to avoid on fire lanes that are relied on for protection: they should be kept clean of all inflammable material, especially during the drier seasons of the year.

That a fire is not always successful in crossing a road may be seen in Fig. 14. Here the foreground has been burned, but a number of pine seedlings in

FIG. 11.—RESULTS OF THE FIRE SHOWN IN FIG. 10, AFTER TRAVELING IN THE DIRECTION OF A WINDFALL.

Fig. 12.—Uneven Topography, which has prevented the Spread of the Fire.

The fire may still be seen burning in the middle distance at the end of the dark streak.

FIG. 13.—A SURFACE FIRE CROSSING A WAGON ROAD ON DRY PINE-NEEDLES.

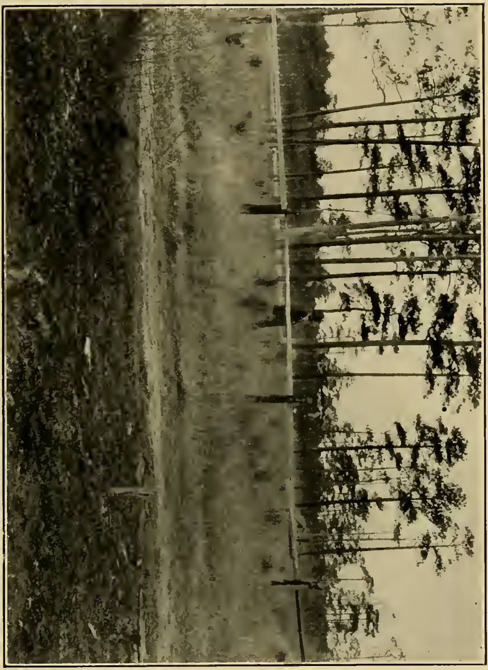

FIG. 14.—A CLEAN ROAD THAT HAS CUT OFF THE FIRE.

the high grass on the further side of the road have escaped.

Fig. 15 shows the long surface-root of a pine, which has been repeatedly burned. The fire has just passed over this place, as may be seen by the crisp, charred needles in the foreground. In the dark spot at the left, where the root enters the ground, it has again caught fire in the inflammable bark and sap, as shown by the smoke rising from that point.

Fig. 16 shows a fire eating into the base of a large longleaf pine. This is the beginning of more deadly work in the future. It required a considerable number of surface fires to make the first opening in the tree, but henceforth the exudation of sap at that place will give future surface fires a great advantage. Fig. 17 illustrates a tree in this advanced stage, with the original scar deep within the foot of the tree.

The rapidity with which surface fires spread depends upon the height and density of the grass and upon the season and wind. In open grass, burning in winter or spring and in still weather, the fire just creeps along and may come to a stop in a short while; whereas in dense grass burning in dry autumn weather under a stiff breeze the flames leap to the crowns of saplings and low poles and would be hard to oppose. In damp seasons a surface fire must occasionally travel around wet hollows or depressions, losing in area and force, though it may afterward regain its original dimensions.

Grass fires are by far the most common kind of surface fires in the longleaf pine forests of the Gulf region, although humus fires frequently occur in the remoter sections in places where a layer of mold has had time to accumulate and replace the natural growth of grass. As compared with grass fires these humus fires are in some respects more and in others less destructive. A partially decomposed cover of dry pine-needles and twigs will burn more slowly than grass, but will yield a hotter fire and one that is probably more destructive to very young seedlings. It possesses the decided advantage, however, of being a low fire, which is not so harmful to larger seedlings and can hardly be repeated, like a grass fire, within the same year. Sometimes the rooting of hogs, which range abundantly through the longleaf pine forests, loosens the mold in places, dries it out, and so prepares the conditions for a higher and swifter surface fire than under ordinary conditions. (See Fig. 18.) On the other hand, there appears to be a greater danger in the case of grass

Fig. 15.—A Burning Surface-root of Longleaf Pine.

Fig. 16.—A Fire burning into the Base of a Longleaf Pine

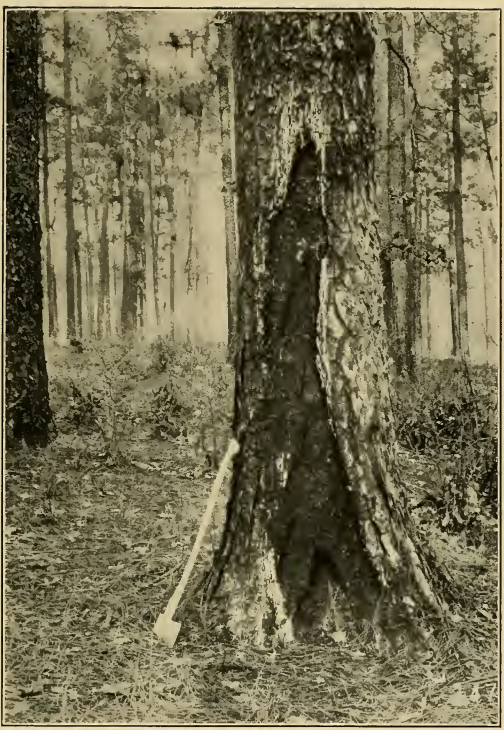

Fig. 17.—A Longleaf Pine that has been repeatedly burned.

fires on account of the difference in the rate of growth of young seedlings, which in all probability is slower in grass soil than in humus soil. This is likely to be so because the humus soil is richer and moister, and also because the grass tends to shade out the young pines.

From the preceding account of surface fires in these forests it will be seen that their progress and mode of action depend upon a number of different circumstances. If we now inquire into the results of these fires we shall find that they are harmful in many different ways.

Probably the most important question in this connection is to ascertain the amount of resistance offered to fire by seedlings and saplings. Without attempting to minimize the immediate and serious harm done to young growth, it may be asserted that the *destruction* of longleaf pine seedlings by surface fires has been somewhat exaggerated and misunderstood; at any rate, so far as concerns seedlings over two or three years of age. Even yearlings may occasionally escape destruction from moderate surface fires. Two such are illustrated in Fig. 19. These had the stem browned and the foliage burned, but the bud within had escaped with a slight singe.

As a rule seedlings of one or two years' growth are destroyed by surface fires. The open forests and dead timber areas of Calcasieu Parish, Louisiana, referred to under Chapter I, will furnish a case in point. In these openings most of the land had been burned over quite recently and seedlings of the year 1899 were at first looked for in vain. Subsequently a few such were found, but most of these had been killed by fire. Finally several small areas were discovered where the grass was high, having evidently escaped the fire. In every one of these areas a plentiful scattering of healthy yearling seedlings was concealed among the high grass.

After the seedlings have attained several years' growth they begin to offer wonderful resistance to surface fires. In the *National Geographic Magazine* for October, 1899, Mr. Gifford Pinchot first called attention to the special adaptations of the longleaf pine for guarding itself against this universal danger. It had been previously assumed that the seedlings were unusually susceptible to injury from fire on account of their very slow height-growth during the first four or five years. The thick, stout bark in these young trees, however, constitutes an unusually effective armor of defense, and the long, dense crop of needles not only shields the bud that is securely

FIG. 18.—MOLD THAT HAS BEEN DISTURBED BY HOGS.

Compare the darker spots in the middle and foreground with the undisturbed surface at the left.

Fig. 19.—Two Yearling Seedlings of Longleaf Pine burned by a Surface Fire but not killed.

hidden within, but hangs about the short stem to the ground to offer it additional protection by shading out some of the grass beneath. In a surface fire this heavy tuft of needles is browned and destroyed, with the exception of a few leaf-bundles close to the bud, but the latter is often saved. When the terminal bud is destroyed, one of the lateral buds may continue the growth. A few illustrations will suffice to show how this is accomplished.

Fig. 20 represents a longleaf pine about five years of age growing at the foot of a mature tree of the same species. The latter, after having been boxed for turpentine, was abandoned and afterward suffered from a very severe fire, as seen by the charred corrugations at the base of the tree. From an inspection of the bark of this tree where it joined the wood at the edge of the scar it could be determined that the fire had occurred within the lifetime of the young tree. One would naturally infer that such a fire close to the young tree must have injured, if it did not entirely destroy, its terminal bud. This was, indeed, what happened, but a lateral bud that had evidently escaped injury continued the upward growth.

Beneath the present healthy terminal bud, shown in the illustration among the foliage tied back, were found the remains of the former terminal bud, which showed indications of the attack of a species of *Ernobius*, an insect that is known to appear after injuries from fire. The stub of this former terminal bud may be seen in Fig. 21 at the angle where the two tufts of foliage have been tied back. Part of the upper foliage has been cut away to expose the present healthy terminal bud at the top of the shoot. In addition this young tree afterward suffered from a severe surface fire, as shown by the thickened and singed bark near the base in Fig. 21.

The following case is still more remarkable:—

In Fig. 22 is seen a longleaf pine sapling with four stubs remaining from previous injuries by fire and insects. Two of these are plainly distinguishable in the illustration, while the other two are indistinctly seen beneath them. As in the preceding instance, this tree has repeatedly recovered from its injuries by the development of lateral buds, the last recovery having taken place three years ago. This sapling, at the time of taking the picture, was about ten years old. On examination it showed recent injuries by insects, both at the foot of the stem and just below the terminal bud. The lower part of the stem also contained a fungus that was growing toward the center. The terminal bud, which was large and

Fig. 20.—Young Longleaf Pine growing beside an Old One that recently has been severely burned.

Fig. 21.—The Young Pine shown in Fig. 20, with its Foliage tied back to expose the Old and the New Bud.

Fig. 22.—Young Longleaf Pine that has recovered repeatedly from Severe Injuries by Fire and Insects.

perfectly healthy, and the heavy tuft of foliage proved the astonishing vitality of this individual.

Although not all seedlings might show such power of resistance, these examples prove that the longleaf pine is in this respect a very remarkable tree. Persistent recovery of the larger seedlings and saplings is not uncommon even on regeneration areas that have been repeatedly exposed to fires. Table V, for example, is based upon an examination of a grove of seedlings and saplings that had withstood many sieges of fire and insects.

An inspection of the table shows that only 3 out of a grand total of 114 trees had been killed by the repeated attacks of fires and insects at the time of examination. Nine trees in column 3 and every tree in column 4 had practically outgrown the danger from fire to terminal buds. Even the smallest seedlings had thus far escaped alive.

These results indicate a marvelous resistance to fires in young longleaf pines, but do not necessarily lead to the assurance that the trees will not die prematurely from the after-effects of such severe and repeated injuries. It is significant that some of the smaller trees were found suffering from the attacks of insects at the roots.

A study of the rate of growth of trees of all

TABLE V.

GROVE OF YOUNG LONGLEAF PINES.
ESCAMBIA COUNTY, FLORIDA.
AREA: 1/10 ACRE.

	Under 9 inches in height (2 years old).	9 to 12 inches in height.	1 to 6 feet in height.	6 to 25 feet in height.
One or more buds recently killed by fire or insects, but generally replaced by accessory buds. *These trees, when examined, were all alive.*		13	11	
Stems blackened by fire. The trees in column 3 retained traces of former severe injuries to buds. *All alive*....	1*		9	74
Uninjured by fire or insects.. .	1			2
Burned to death, retaining neither foliage nor buds.. . .		1	2	
Totals..................	2	14	22	76
Grand Total........	 114			

* This seedling had sustained injury from fire not only on the stem, but also in the foliage.

sizes taken from this sample grove showed that while the trees in columns 1, 2 and 3 (partly) had made very slow progress, many of those in column 4 were growing vigorously and making long, healthy annual shoots; but scars found within the stems indicated that these trees had also in their earlier life been subjected to severe fires and had, like the smaller trees, been retarded in their growth.

In conclusion the following harmful results of surface fires should be noted:—

1. They undoubtedly destroy a considerable number of seeds, occurring as they do at all seasons and being particularly severe in the fall of the year.

2. While seedlings offer a remarkable resistance to injury from fires, those under two years of age rarely escape. Even among older seedlings a certain proportion is killed where fires occur at frequent intervals.

3. The injuries to the bark and buds of saplings and young trees sometimes lead to unsoundness as the trees grow older. In mature trees recurring fires may gradually burn into the lower parts of the trunk, lessening its value and so weakening the tree as to expose it to the danger of being thrown by the wind.

4. The constant repetition of surface fires greatly impoverishes both the seed-bed and the soil. The mold, which not only furnishes nutrition but also protects and improves the condition of the soil, is thereby destroyed, and the germination of seeds as well as the growth of trees at all ages is unfavorably affected.

V

The Soil Cover

WIRE-grass, broom-sedge and forest mold are the usual forms of soil cover found within the longleaf pine forests of the Gulf region. The great preponderance of grassy areas over areas covered with forest mold at first gives the impression that grass furnishes a natural condition for superior development. But to assume this would be a hasty conclusion. True, it is only in the denser parts of the forest and in places that have escaped fire for a number of years in succession, that a substantial mold of pine-needles can be found; yet there is no doubt that such a soil cover is superior to a growth of grass in its effects upon the soil. Experience has shown it to be so not only in Europe, where the subject has been exhaustively studied, but also in this country. An examination of the soil in different parts of the longleaf pine region showed that when covered with a good layer of mold it was invariably moister and mellower, as well as more uniform in texture and quality from top to bottom, than the soil found under wire-grass. Its darker color also showed that it had been enriched by the decaying vegetable matter that covered it.

Aside from their immediate effects upon the soil, however, it would be interesting to know something about the respective merits of these two forms of soil cover as mediums for germination. Unfortunately, tracts where reproduction can be studied on humus and grass soils under otherwise similar conditions are rare; but a single instance will suffice to show at least the direction in which the preference lies. An opportunity for a careful comparison was found in a small opening within a virgin forest in Catahoula Parish, Louisiana. This opening had been but recently made. The soil was a fresh sandy loam of excellent quality, and was covered in one part of the area with dry pine-needles nearly an inch in depth; in another with the charred remnants of a similar humus cover, the burned needles having been largely washed away; and in a third with grass 8 inches high, which had a scattering of pine-needles hanging here and there among the blades. These three sub-areas were about equal in size, contiguous to each other, and exposed to the same conditions of light. The area as a whole faced a larger opening toward the south and was enclosed on the other three sides by mature old trees.

This tract, which was examined on January 25th, contained a number of very young seedlings which were just beginning to push their heads through the humus and grass. A few of these are shown in Fig. 23. Within each of the three sub-areas squares of four yards to a side were measured off and the number of seeds and seedlings, together with certain other facts, were carefully determined, with the following results:—

TABLE VI.

Sample Plots Showing the Superiority of a Humus Cover Over a Grass Cover for Germination.

Plot 1. Humus soil cover.		Plot 2. Same, burned and washed.		Plot 3. Grass soil cover.	
Seeds.	Seedlings.	Seeds.	Seedlings.	Seeds.	Seedlings.
None	47	5	36	8	8
	One was frozen.	One was burnt.*	Three were frozen.	All were hanging in the grass, unable to reach the soil.	Four were frozen.

* The fire on this sub-area probably occurred before most of the seeds had fallen.

FIG. 23.—SPECIMEN SEEDLINGS FOUND ON JANUARY 25TH IN CATAHOULA PARISH, LOUISIANA.

Without proving exact proportionate figures for other areas, these results suggest some important conclusions:—

1. A natural soil cover of needle mold is the most favorable condition for the germination of seeds of longleaf pine.

2. A bare soil is slightly colder and is, moreover, subject to surface washing; it is therefore less favorable to germination.

3. A grass cover is subject to frosts. Moreover, it constitutes a physical obstruction to the winged seeds of longleaf pine, preventing many from reaching the soil and also exposing them to destruction by birds and rodents.

VI

Injury to Seedlings Caused by Hogs

THE reader's attention has already been directed to the loosening of the soil cover by hogs and the tendency that this has to promote the spread of surface fires (p. 64). This source of danger, however, is slight when compared with the immense destruction they do among the seedlings. Ranging freely through the forest, they seek out the youngest and tenderest plants and feed upon the soft, succulent roots, stripping the bark and leaving the mutilated remnants to dry and shrivel in the open ground. They also devour many of the seeds.

The keeping of hogs is almost universal among farmers and settlers throughout the longleaf pine belt and has always been considered a serious menace to reproduction by those who have made a careful study of this question.*

* "The Forests, Forest Lands, and Forest Products of Eastern North Carolina"; Bulletin No. 5, North Carolina Geological Survey. By W. W. Ashe. "The Timber Pines of the Southern United States"; Bulletin No. 13, Forest Service, U. S. Department of Agriculture. By Charles Mohr, Ph.D.

VII

Rate of Growth in Virgin Forest

IN the course of this investigation 19 complete "stem analyses" were made of trees that had very recently been cut in virgin forest; 41 additional analyses, confined to the stumps of the trees, were similarly made in freshly cut areas, and the ages and corresponding diameters of 22 trees over and above the preceding were also determined. These data were gathered from all sections. The total number, while entirely too small to give reliable figures for the usual purposes of such analyses, is still large enough to enable us to draw a few interesting conclusions regarding the rate of growth of the longleaf pine.

It is well known that a relation exists between the crown of a tree and its rate of growth in diameter. The larger the amount of foliage the greater is the quantity of food that can be assimilated, and consequently the wider are the annual rings of growth likely to be. The changeable conditions in virgin forests usually result in a corresponding variability in the diameter development of the trees, even when they are of the same species and are growing on the same area. On account of the "intolerance" of the longleaf pine, however, its crown, as a rule, is comparatively short; or, if long, it is likely to be quite open in its lower parts. One would therefore expect to find a closer correspondence between age and diameter in comparing individuals of this species than in other trees. A careful study of the data collected bears out the correctness of this theory. Notwithstanding the differences in the conditions of the several localities from which the trees were selected the diameters were found to keep within reasonable limits of the ages, except in sapling groups and in one or two unusually open forests.

In open stands one would naturally expect to find greater variations in the relation of age to diameter than in dense stands. In open stands the older trees are receiving the full benefit of the sunlight and are therefore able to develop long and ample crowns, while the younger trees, being occasionally overtopped, are less fortunate in their positions.

These differences in the rates of diameter growth, provided they show consistently a more rapid development for the older trees, are in reality a further indication of the "intolerance" of the longleaf pine. To determine to what extent this might be true, a sample $\frac{1}{2}$-acre tract having open forest conditions was selected for a comparison of the rates of growth. On this tract the diameters of all the trees at 3 feet above the ground and the number of years' growth, as shown by the annual rings at that section, were determined. It was not possible to obtain measurements in the upper sections of the trees, which might otherwise have supplied additional facts in support of this principle, although the measurements that were taken show consistency in themselves.

The results of these measurements are represented graphically in Diagram 1, which shows the progress of diameter development for the complete stand, the history of growth being indicated by a line for each tree.* On account of the open character of the stand the lines naturally show unusual diversity. Notwithstanding the low density of .5, however, the curves for the younger trees indicate a retarded

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* The diameters at breast-height (including bark), the number of trees of each diameter, and the silvical conditions may be seen at a glance by referring to plot 6 in Table II.

diameter development when compared with older trees at corresponding ages, thus showing in a very interesting way the "intolerant" habit of the longleaf pine.

During the first thirty years the divergence of lines is not sufficiently marked to indicate the probable future development, but after that period the relations of growth between older and younger trees are shown with more consistency. A retarded diameter development for younger trees is shown when we compare the elevations of lines 21, 22, 23, 25 and 26, between the ages of 30 and 140 years, with the elevations at corresponding ages of lines 1, 2, 3, 4, 5, 7, 8, 10, 11, 12 and 14: Even tree No. 24 remains below most of these older trees. Exceptions like that of No. 20, as compared with Nos. 6, 9, 15 and 16, must, of course, be expected in a natural forest, subject as it is to constant changes.

Taken together, the lines evidently point to more favorable light conditions for the older than for the younger trees. The quick succession of the earlier age groups * would seem to indicate that the present

* On account of the extreme difficulty of determining the exact age of longleaf pines, the seed years that came within five years of one another were adjusted to the same date; as shown, for instance, by the ages 140, 185 and 209.

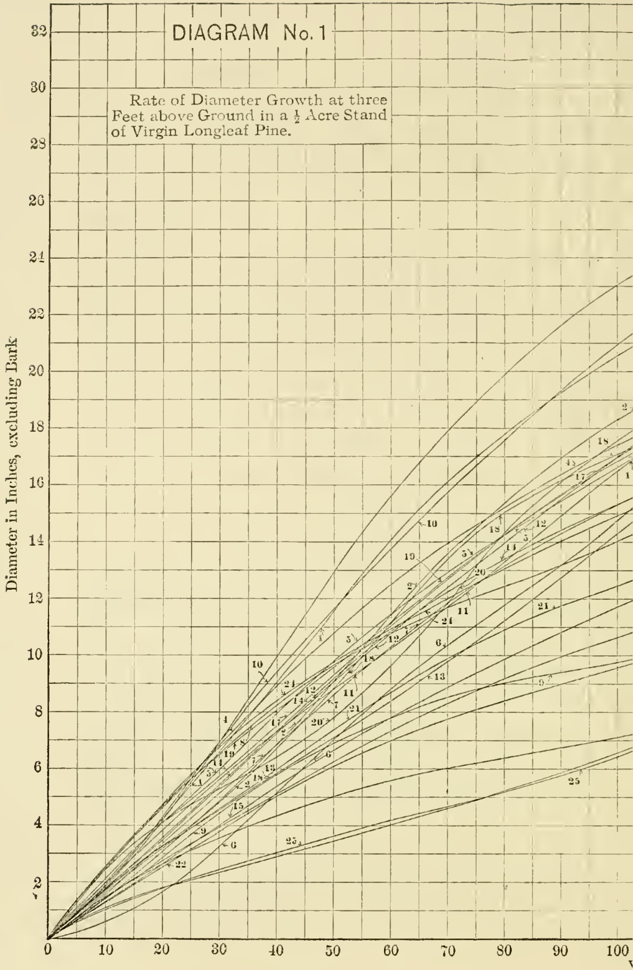
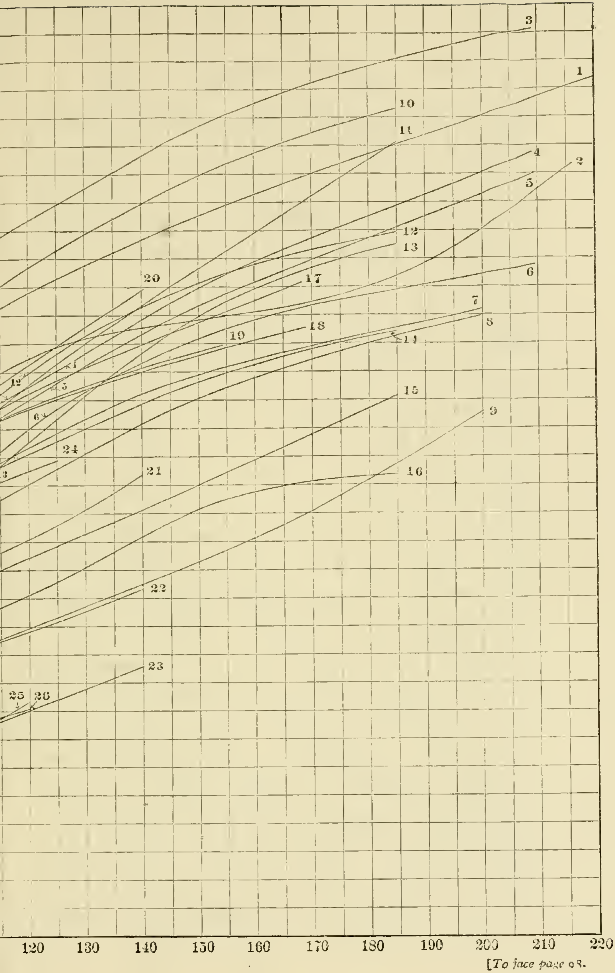


DIAGRAM No. 1
Rate of Diameter Growth at three Feet above Ground in a ½ Acre Stand of Virgin Longleaf Pine.
Diameter in Inches, excluding Bark
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100



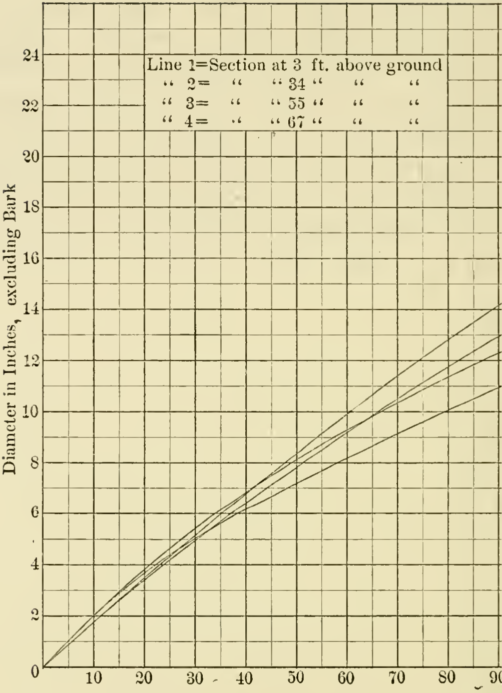
[To face page 98.

stand followed some sudden opening, possibly resulting from a severe storm or a complete destruction by insects. The curves show that as soon as the ground began to be moderately well stocked with trees—including some, undoubtedly, that did not survive the earlier periods of growth—subsequent accessions to the tract occurred only at wide intervals, and ceased altogether as long as one hundred and twenty years ago. This early decrease and apparently premature cessation of new growth with the advancing age of the stand will be the more readily understood when it is remembered how strongly developed is the need for overhead light in the longleaf pine and how soon, owing to the rapid height growth of this tree, the direct sunlight is shut off for the seedlings and younger trees of the forest.

In the curves of Diagram 1 the slow diameter growth in the lower part of the stem in old trees is less marked than usual, possibly because the stand was somewhat below the average density. It is more evident in line 1 of Diagram 2, which represents the average progress in diameter growth at 3 feet above ground of ten dominant longleaf pines selected from various localities. Notwithstanding the advantage that these trees must have had as leaders in the forest, the curve shows that they were growing only very slowly near the base during the last forty years. This is because they were overaged. But lines 2, 3 and 4, which represent sections at various heights above ground in the same trees, show by their persistent ascent that the trees were still adding a fair increment when compared with that in the lower part of the tree.

This is important, because the longleaf pine is thereby able to produce the cylindrical, full-boled timber that is so desirable in the market.

D



Average Rate of Diameter Growth

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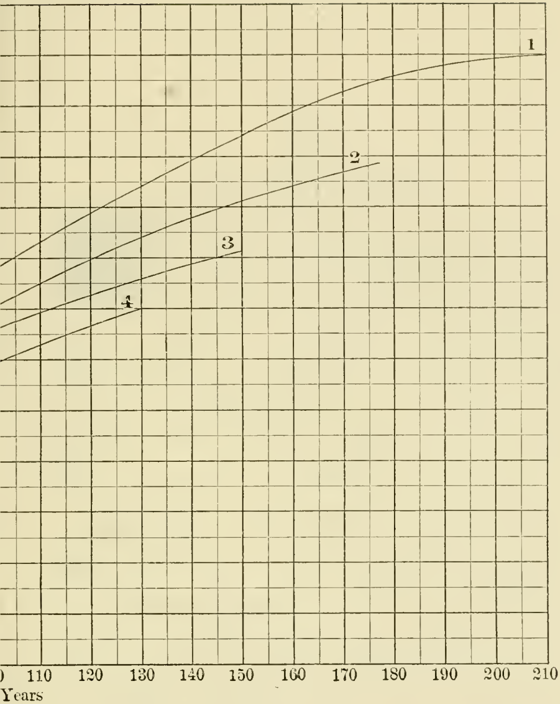

: Sections in ten Dominant Longleaf Pines.

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VIII

Forest Management

FORESTS are of benefit to man in many ways. They furnish him with a thousand necessities, they regulate and purify the flow of streams in mountainous regions, improve soil conditions and prevent landslides and floods, purify the air and moderate the extremes of temperature, serve as windbreaks and protective belts, and they uplift man morally and add to the beauty and enjoyment of the world.

If this were a general treatise on forests instead of only a silvical study, it might be proper to devote some space to the beneficial influences of longleaf pine forests on climate and health, and to the picturesque forms of these trees and the charm and beauty of the forest scenes throughout these Southern pineries. For this is not only a very useful tree, but one of high æsthetic value also. Its long, bushy tufts of needles, the interesting and expressive crown-forms lifted high up on the straight trunks; the openness of the forest, isolating the trees and emphasizing their individual characters; the beautiful color contrasts of dark-green foliage, brown trunk and tawny grass; the open glades and occasional wide savannas within the forest, furnishing foregrounds and framing the views; and the magnificent backgrounds of sky and cloud, as seen through the trees or looking across the forest from some low hill—these are only suggestions of the features of beauty and the landscape values to be found in virgin forests of the longleaf pine. A silvical study, however, naturally leads to the economic side of the question, and its practical value will largely consist in the suggestions it can offer for the proper management of the forest.

Economically the longleaf pine is one of our most important forest trees. Its geographical range is a very extended one and it has high commercial value and broad general usefulness. The forests may be lumbered with comparative ease. Moreover, their character of growth is of still further practical advantage, because it easily adjusts itself to a simple, straightforward method of management.

If the forest is to yield its best and the supplies are to last not only for the present but also for future generations, it must be protected against fires and other serious dangers, and a method of exploitation must be adopted that is based upon the natural requirements of the tree and that will insure the reproduction and future development of the forest.

Although young longleaf pines show a remarkable capacity for recovering from the effects of fires, protection against this universal danger is absolutely imperative. It will be remembered that very young seedlings are usually killed by fire, while in oft-repeated fires or in very intense ones, like those caused by the tops and branches left on the ground after logging, seedlings of more advanced growth may be destroyed. A dense, healthy reproduction is necessary to insure a normal and healthy forest in the future.

The underlying condition for the successful protection of the forest against fires is a proper sentiment among the people. The population living among these pine forests is scattered and irresponsible and few recognize the importance of avoiding fires in the woods. State laws should be enacted and enforced. A special fire guard, or several on larger tracts, should be employed to patrol the forest. Tool-houses for the storage of the necessary implements for fighting fires should be erected in convenient places. It should be the duty of the fire guards to patrol the woods regularly, especially during dry periods and immediately after seed years. They should familiarize themselves thoroughly with the conditions in all sections of the forest and should submit regular reports. They should keep roads and artificial fire lanes, where such have been constructed, clear of all inflammable material, and should be enabled to call for assistance to extinguish any serious fires that may have started. On large properties a telephone system will prove of advantage in quickly summoning aid when necessary.

For the proper protection of seedlings and young trees in the forest special attention should be directed to the disposal of the slashings that remain after lumbering. Too often these are allowed to lie scattered about, exposed to the drying influences of wind and sun, constituting a serious menace in case of fire to the little seedlings that now begin to appear in the openings. There are instances where slashings may be helpful to the young growth, for the conditions of climate and soil and the composition and character of our forests vary greatly; but almost everywhere, and certainly in the pine-lands of the South, the removal of these slashings is desirable. They should immediately be piled in heaps and burned during moist weather, when any spread of the fire may be easily controlled. If this is impracticable, the larger material should at least be drawn away from trees and tree groups left standing, and the boughs and branches should be lopped from the tops so as to bring them into closer contact with the earth and hasten decay.

The importance of young growth in the forest, though clearly recognized by the forester, is often overlooked by the timber owner and rarely understood in its full significance by the general public. Reproduction is, indeed, one of the vital problems of forestry to-day, for it is this young generation of trees that must ultimately replace the older generation that is now passing away. We should therefore do our utmost to protect and lead into their future estate the seedlings and saplings of the forest.

Another source of injury to our longleaf pine forests is the crude method still commonly followed in tapping the trees for resin. They are roughly hollowed out or "boxed" at the base and deeply scarred along the trunk to promote the resin-flow. The result is that most of the trees are weakened in their growth, and their power of resistance to the attacks of insects is greatly lessened. Many are killed and thousands are overturned or broken off in storms. Finally the forest fire, eating into the bases of the live trees and burning among the dead ones, leaves behind some of the most wretched and disheartening of our forest scenes. The more intelligent methods of turpentining long practised in France and recently introduced through the U. S. Forest Service with certain improvements and modifications into our own country, should be widely adopted, for they are not only more profitable and economical, but far less injurious to the forest.

Still further protection is possible by exercising more care in the cutting of trees. In logging operations the young and middle-aged growth is often injured through careless methods of felling. Large trees are allowed to crash into young saplings and poles, because these as yet have no commercial value. Occasionally a tree in felling lodges in the crown of another, and if its removal is awkward it is wrongly allowed to remain. Such losses can usually be prevented. The direction in which a tree is thrown should be so chosen, if there is a choice, as to avoid the crowns of other trees and do the least possible harm among the younger growth.

Finally, the young growth must also be protected against injury from live stock of all kinds. The larger animals trample and bruise the young and tender seedlings; sheep and goats are known to browse on the buds; and hogs, which are most plentiful and common, do serious harm by tearing up the sweet, succulent roots. It is unfortunately the custom in these Southern pineries to set fire to the tall wire-grass in order to improve the grazing. This practice does not only injure the trees and impoverish the soil, but young seedlings are in constant danger of destruction. It would be far better to confine grazing and the hog range to sections of the forest where they might be conducted under normal conditions. Under such protection the forest floor would gradually accumulate a natural forest mold and in certain places the grazing would actually be improved by the ultimate replacement of the present inferior surfacegrowth by better kinds of grasses.

With the idea of protection is linked the idea of utilization and perpetuation of the forest. In plans for technical forest management in the United States it has heretofore been the usual practice in the larger undertakings to base such plans chiefly upon a very elaborate and thorough study of the rate of growth of the trees, and to advise the forest owner to cut only to a certain diameter limit. It will be understood that each species of tree, when growing under given conditions, reaches a time in life when the rate of growth from the financial standpoint is at its maximum,—when the tree is adding more rapidly than it did before, or will hereafter, to its merchantable contents, which in most of the important trees of commerce is synonymous with its contents in board-feet. The rate of growth is, of course, a very important consideration, but it is by no means the only one. Although the rate may fall off after a certain period has been reached, the gradual increase in size of the trees thereafter will produce proportionately more valuable dimensions and better grades of timber. What is perhaps still more important, the value of timber itself is increasing in our country year by year, for the supplies are undoubtedly diminishing much more rapidly than the forests are adding to those supplies by their growth. It should not be forgotten that we have heretofore taken out the very best and usually left the less promising trees, which in their turn have fared ill as the result of fire, insect attacks, windstorms and general neglect.

It is true, on the other hand, that there are certain practical points to be considered by the timberland owner. He may find it easier and somewhat cheaper in logging operations to take out more trees at one time and, by abandoning the remnant, to overcome the expense of taxation and protection of the forest during the long period of the future. He may also find it an inducement to take a certain small profit out of small trees now and re-invest that profit with interest, rather than let the forest itself multiply the interest in the form of valuable timber. But it would be a hasty conclusion to infer that these advantages would outweigh those that have been suggested in connection with the maximum rate of growth, improvement in grade and quality, and steady enhancement in commercial value.

It is the prevailing custom at present in the Gulf section of the longleaf pine belt to cut down to a diameter limit of usually not less than ten inches, and in some places not under twelve. Trees less than ten inches in diameter yield but a few board-feet of timber. Diameter limits of fourteen, sixteen and even eighteen inches, at breast-height, have been recently recommended by the U. S. Forest Service. The different limits are based upon careful studies of the local conditions. Considering that the longleaf pine, as shown by such studies, still maintains a rapid rate of growth at average ages corresponding to the diameter of sixteen inches, and considering the greater value of large dimensions and the general rise in timber values, an average cutting limit of sixteen inches for longleaf pine (assuming some fixed limit to be desirable) appears by no means too high.

There is another important consideration that should enter into every plan of treatment for the exploitation and perpetuation of the forest. This is the silvical consideration. What are the conditions of life in the forest and in what relations do different kinds of trees stand to one another? How much seed do they bear, at what ages and in what intervals, and how is the seed conveyed for germination to various distances from the tree? How are germination and later growth affected by variations in the soil and soil cover, by slope or geographical direction, by altitude? What is the ideal for each kind of tree with regard to moisture, warmth and sunlight? And in what way does the density of the stand and the intermingling of many species affect the forms of the trees and their rapidity of growth?

It appears to the writer that the time has come when such questions deserve even more careful consideration than they have hitherto received. A study of the rate of growth and the determination of a diameter limit will often have considerable practical value, especially in the case of "pure" forests; but where the trees occur in mixture one can hardly predict what the effect will be upon the future development of the forest when the trees of only certain selected species, down to fixed sizes, are removed. For certain complex forests are like nations, where the battle of life has followed the lines of least resistance and the individuals have gradually accepted a series of necessary adjustments. When, by a thoroughly intelligent silvical method of treatment, our forests shall have been converted gradually into forms of more abundant and varied usefulness and shall, in a manner, have become fixed and systematized, the questions of rates of growth and future yield can be approached, even in the case of mixed forests, with far more assurance. The forest owner will hardly be the loser if, in addition to the measurements of growth, he gives to silvical questions, on which the life and the whole future of the forest depend, the full attention which they deserve. He may thereby sacrifice some profit in the immediate present, but the time seems to be near at hand when the silvical condition of a forest will have its recognized value and may be looked upon as a convertible asset.

If some systematic method be now sought for in the management of longleaf pine forests, it will be well first to glance again at the natural conditions under which they grow and upon which such a method should be based. Like most of the conifers the longleaf pine occurs mainly in the form of "pure" stands: it mingles with other trees only over certain restricted parts of its range. The topography of the country is generally level or undulating, the forests are unusually open, and there is comparatively little underbrush except in the heavily cut-over and burned tracts on the Atlantic side. The forests are also characterized by frequent transitions in the ages and in the density of growth, so that the effect is often that of a succession of large and small groves, either gradually merging into one another or changing abruptly from young and dense to mature and opener growth, or to a mixture of variable sizes and ages. The trees themselves are remarkably straight and clear-boled, being but little affected in this regard by the openness of the stands. These conditions greatly facilitate the felling, sectioning and transportation of the timber, while the mildness of the climate makes it possible to continue operations practically throughout the year.

On the other hand, however, the longleaf pine withstands only a moderate amount of shade and the seed years are infrequent.

Under these conditions the efforts of the forester should be directed, first of all, toward a conversion of the present somewhat irregular stand into one having a more complete and regular succession of age-classes and a more equal distribution of the areas within each age-class. This will systematize the annual yield and make the forest continuously productive. To accomplish this, the most practicable method of cutting that suggests itself is a separation of the older and merchantable groves from the younger ones and from those in which trees of different sizes are mingled together. Each of these types of growth will require some modification of treatment. The older groves are now ready for the axe and if a diameter limit, as, for example, sixteen inches be chosen, the greater number of trees on such areas will be removed. To insure the renewal of the forest on these areas it will be necessary to leave standing *at least* two or three well-grown healthy seed trees per acre, as evenly distributed over the area as possible. If it should happen that a considerable number of trees below the diameter limit occur on the selected area, it may be possible to dispense with one or more of the special reserve trees. It may even be desirable to remove some of the trees under the diameter limit, either because they are defective or ill-shaped and therefore occupy space out of proportion to their worth, or in order to admit more light to insure a successful reproduction. Sometimes it will be found more convenient to raise or lower the diameter limit slightly, in order to meet particular conditions on different parts of the tract.

In determining the number of reserve or additional trees to be retained the conditions on each local area should be considered independently, and it should be remembered that there will probably be some loss from windfall among the reserved trees; although, if chosen carefully, such windfalls should not be excessive, as the groves are usually of moderate extent and will thus be protected by adjoining forest growth. On areas of less than one acre it will hardly be necessary to reserve seed trees, provided such areas are surrounded by stands which include seed trees along their edges.

After a dense and healthy reproduction has been established, the reserve trees should be removed if the new young growth requires such removal; otherwise they may be retained for a second rotation or for future cutting in connection with neighboring areas.

In groves in which the trees vary considerably in size, the method of cutting should be modified to suit that condition. A fixed diameter limit will not always be practicable or desirable. The object should be to utilize the larger trees within these groves and to select them in such a way as either to benefit the remaining trees—that is, by giving them more light and growing space—or to inaugurate a successful reproduction. On account of the variations in diameter and height and in density of growth the method of treatment will require careful discrimination and judgment. Where single large trees or groups of large trees are interspersed among much younger ones of approximately uniform size, the larger trees, being merchantable, should obviously be removed. Sometimes the openings thus made will be large enough to insure reproduction. Where they are not quite large enough and are surrounded by younger but still merchantable growth, it will in some cases be advisable to cut into the latter in order to enlarge the opening.

It will often happen, on the other hand, that the grove can best be dealt with by means of an "improvement thinning." In such thinnings selected trees of the intermediate and larger sizes are removed not only for their own use, but also for the benefit of the trees left standing. The cut in such cases will usually be a moderate one, because a renewal of the stand is not intended and, indeed, a scant or partial reproduction would be undesirable. The stand is merely being prepared to make a more satisfactory growth in the future. As a result of the selected removals it will become much more uniform, and at a subsequent cutting-period can be dealt with similarly to the older groves for which a diameter limit has been adopted.

The variable character of growth does not always make it possible to differentiate clearly between the groves of trees of unequal sizes and those in which the stand is mainly a mature and merchantable one. Here there is an opportunity to exercise individual judgment. It will usually be more advantageous if the grove can be classed with those intended for clear cutting with reserve trees, and it is believed that by far the greater number of the areas can be treated in that way.

In dense young groves in the pole stage, resulting from the fall of a single large tree or a group of trees at some former period, improvement thinnings will likewise be of advantage. These should be carried out in such a manner as to leave standing the straightest and most promising trees and to cut out those whose presence interferes with their development. The object of this treatment is to better the quality of the stand and to increase its rate of growth.

The method of exploitation outlined in the foregoing paragraphs is in certain respects similar to that recently adopted for the *Chir* forests of India, a tree that, like the longleaf pine, is intolerant of shade and grows mainly in the form of pure stands. It will be seen that this method results in a systematized subdivision of the tract into numerous small areas, which will ultimately be separable into certain fixed age-classes. For it is not to be supposed that all the small groves of mature forest growth will be logged at once. On larger holdings, which are the most common in this region, it would require a series of years to log these areas. By exercising some care in their selection it would be quite possible to distribute the yield with approximate equality year by year, throughout the first natural rotation. The groves of variable growth, to be treated in the manner already described, would, of course, likewise be included in this first rotation of the forest.

If the principle of an equal distribution on the basis of area were to be adopted during this first rotation, the second rotation or cycle of the forest would approach much more closely to an even annual distribution of the yield. The total of areas annually to be logged during this second rotation would evidently be equal, year for year; but the yield would, of course, still vary to some degree on account of inequalities in the original reproduction, variations in the soil and other natural conditions, and the success or failure of protection on different parts of the tract.

IX

The Æsthetics of Forestry

IN the foregoing chapter an attempt has been made to explain the meaning of "forest management" and to outline a method of treatment fitted for longleaf pine forests. That is the economic side of the subject, which naturally deserves first attention in a book the purpose of which is mainly practical; but the side which appeals to the imagination cannot be entirely ignored. The sentiment for the beauty of trees and forests, which until a few years ago was still confused in the minds of many people with the practical aims of forestry itself, was—for that reason, perhaps—until quite recently regarded with indifference by professional foresters and timberland owners. There was a feeling that it might interfere with practical administration. Yet in itself a love for natural beauty is a worthy sentiment; nor has it been shown that forest beauty and forest use are incompatible with each other. Within a few years a closer understanding of the economic principles of forestry has spread among the people, the science itself is being built up on the basis of our natural and economic conditions, and its practical application is extending into every part of the country. And now, also, professional foresters are beginning here and there to express their ideas about the value of forest beauty and its relation to economic forestry.

The greater part of our forests is owned in extensive tracts by large corporations and individual lumbermen and by farmers in the form of small woodlots attached to the farm. The national government, which has added year by year to the national forests, now administers a total area of such forests amounting to nearly 231,000 square miles,* although that is still only a minor part of the total forest area of the country. There are also private forest estates held for other than financial reasons, but they constitute only a small part of the whole. When we think of all this vast forest wealth and how important a feature it is in the landscape values throughout the whole country, we naturally ask whether something cannot be

* April 1, 1907.

done to keep intact its beauty, or to evolve new features of attractiveness in connection with the forestry methods to be applied; or, if not, we would still be interested to know in what ways forest scenery is modified by technical forest management.

It is not a question of transforming forests by art into parks, nor of withholding the forests from legitimate use in the life of the nation. In most cases financial considerations will govern the individual owner in the management of his forest. A range of woods may, however, have even greater actual and marketable value as a piece of landscape, or its value may be due at least partly to the beauty of its scenery. There are, moreover, instances where a forest estate, or a bit of picturesque woodland, though it may not be directly saleable as such, still is more precious in the eyes of its owner than would be the financial returns from the cutting of the trees.

Our national forests, on the other hand, are held as a trust for the people. They are precious to us because they will help to furnish the indispensable timber supplies of the future, and they are equally important because they conserve the water supply and regulate the flow of hundreds of streams that find their way down from the mountain ranges over a vast territory. Is it too much to ask that here and there a small reserve be set aside within these forests for the sake of its beauty and wildness? Our national parks, splendid specimens of nature's handiwork as they are, do not sufficiently represent the great variety and magnificence of our natural forest scenes. Within these places we and those who shall follow us might realize the restfulness and beauty of the primeval forest. These special reserves would also have a real scientific value for botanists, biologists, and—most of all—for foresters themselves.

Æsthetic forestry, in the minds of many of us, is still a vague and confusing concept. Is it simply landscape architecture applied to woodlands? Why then employ the term forestry? The question depends upon the point of view. The fact is, the "wisest use of the forest" obliges us to consider all its uses. If our enjoyment of the æsthetic qualities is a real or a possible one, forest beauty has a distinct value and deserves to be considered together with other values. The point that is so often overlooked in this connection is this: that the technical work which is applied to the forest has far-reaching effects upon the expression of the trees and the character of the forest scenes. For the person for whom forest beauty has a meaning, the æsthetic element is thus forced into the question of practical forestry, whether that was the intention or not. It is worth our while to consider, in a few words, what the results of technical forestry upon the character of the forest may be.

First, technical forest management produces orderly effects in the forest and systematizes the scenery. It consequently destroys the element of perfect wildness and naturalness, on which so much of the charm of forest impressions depends. But at the same time it eliminates the decrepit and valueless trees, though it also tends to reduce the variety of the different kinds. The trees that remain may be less picturesque, they may be less expressive in their forms, less gnarled, not so old, and perhaps less interesting; yet they will often be straighter, thriftier, healthier trees. A human purpose now runs through the forest, and if the management be careful and thorough its appearance will be neat and orderly, like a well-kept house.

There is also a certain gratification that depends upon mere technical excellence, and not upon outward forms, that undoubtedly comes to every forester interested in his work. This is a mental satisfaction, like that of the scientist or inventor in the outcome of his investigations, and may be experienced even when the visible results of the work happen to have no æsthetic value. Such a sense of satisfaction, however, is quite different from the real pleasure which is derived from the healthful aspect and orderly arrangement of the forest. It would therefore be a mistake—and it is one easily committed by the technical enthusiast—to call certain effects beautiful merely because they appeal to his mental attitude toward the subject.

Secondly, technical forest management may add new elements of beauty to the forest, may even produce artistic effects when there is no intention of doing so. Thus, in the plan of management for the longleaf pine which has been outlined in the preceding chapter, it is not difficult to visualize some of the transformations that would ultimately take place in the scenery of the forest. The method of selection that was recommended for the groves having variable stands would isolate some of the most promising trees and tree groups from the surrounding growth, would thereby encourage their development, and would ultimately bring out more effectively their characters and individual expressions. Far more striking results would follow on the areas of clear cutting with reserve trees. At present, although there are occasional glades and openings in the forest, the growth as a whole is continuous. There is consequently a lack of foregrounds: the forest views cannot be fully appreciated, because we cannot step back to observe them at a proper distance. With the cutting out of certain groves, however, and the retention of a few trees within these groves, the remaining stand at once becomes more picturesque. As the observer walks through the forest a succession of pleasing contrasts is presented to the eye. Groves and groups of trees are changing, as seen nearer or farther away and from different angles of view, while new vistas are continually appearing in the distance. The reserve trees stand out boldly against the background of sky, tall and erect above the dense thickets of seedlings and saplings at their feet, presenting a contrast between the passing generation and the new one that shall step into its place.

These are examples of the possible æsthetic effects due to the application of forest management, and it is hardly necessary to say that in this case they were not preconceived in the plan of management that has been outlined in the preceding chapter. Nor must it be forgotten that technical forest management may interfere with or destroy æsthetic value in the forest just as readily as it may create it. Recurring again to our example of the longleaf pine, a look into the far future will show that the picturesqueness and beauty referred to in the last paragraph is only of a transitional nature. In the end the forest becomes separated into a succession of distinct age-classes, each age-class uniform in appearance. The forest has become more artificial without being artistic and is no longer as pleasing to the eye.

If the ideas set forth in the preceding paragraphs are substantially correct, the opinion that has occasionally been expressed in publications devoted to forestry, that mere technical management will of itself take care of the beauty of the forest, is not well founded. There is a great deal that can be done by intelligently considering the æsthetic values of the forest. While in a large majority of cases the practical idea of usefulness and profit must be the dominant one, there are others where some consideration of the artistic effects is justifiable, provided it does not interfere seriously with the economic plan of management. Simple measures are often quite as effective as those that are more pretentious and elaborate. Whatever is done to make the fo- a more attractive and inspiring place to be in, should be done with a clear conception of its meaning: the measures adopted should harmonize with one another and be directed toward a well-conceived purpose.

It is true that the love of nature and an appreciation of its forms of beauty comes to men in different measure. But an understanding for these things can surely be cultivated by observation and study. Few have as good opportunities as the forester to study the ways of nature, and much that has to do with art and æsthetics can be gathered from the books.

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